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Sex ratio and size range of small cetaceans in the fisheries catch on the west coast of Sri Lanka

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Abstract

This study examined the sex ratios and size range of small cetaceans caught on the west coast of Sri Lanka, in the fish landing sites of Beruwala and Negombo, where accidental entrapment and intentional harpooning occurs. Monitoring was done from May to October 1994.

A total of 588 specimens of 12 species (*Stenella longirostris, Stenella coeruleoalba, Stenella attenuata, Tursiops truncatus, Grampus griseus, Peponocephala electra, Pseudorca crassidens, Feresa attenuata, Kogia breviceps, Kogia simus, Steno bredanensis, Lagenodelphis hosei*) were recorded. The proportion of sexes was significantly different between sites. In most species females were longer than males but there was no significant sexual dimorphism in any species recorded. In most commonly caught species a larger percentage were juveniles and sub-adults.

The study concludes that there is a female bias in the catch at Beruwala with the overal number of females caught being significantly higher than the number of males. A significant difference between sites in the size of males of the species *Stenella longirostris* and females of *Tursiops truncatus* indicates that more than one form (coastal and offshore) of these species may occur around Sri Lanka, similar to previous records from the eastern tropical Pacific for *S. longirostris* and from the north Pacific for *T. truncatus.* A larger percentage of juveniles and sub-adults being caught indicates the possibility of an adverse impact on populations in the future due to an eventual dearth of breeding adults and diminishing replacement levels.

Key Words : small cetacean, sex ratios, size range, capture method.

1. Introduction

Until the past two decades the occurrence of small cetaceans off the shores of Sri Lanka was poorly documented. Since the early 1980's some research on cetaceans, concentrating on the occurrence of large whales has been carried out and in the course of these studies some 20 species of small cetaceans have been identified as occurring in Sri Lanka's territorial waters. In the course of these studies it was also discovered that small cetaceans were being killed in the fisheries industry, both as an accidental by catch in gillnets and through an intentional catch using hand held harpoons. While most of the previous studies which included a component on small cetaceans concentrated on trying to estimate annual catch rates, the results of successive studies yielded extremely disparate estimates, ranging from a high of 49,863 (LEATHERWOOD and REEVES 1989) subsequently revised to between 8,042 and 11,821 (LEATHERWOOD 1990), to a low of 5,181 (DAYARATNE and JOSEPH 1993). Little information was gathered on sex ratio, size range etc. In most studies and even where such information was gathered statistical methods were not used in analyzing this data.

The present study was therefore undertaken for the purpose of examining sex ratios, adult/juvenile ratios based on morphometric measurements and correlation between capture method and size/maturity of small cetaceans in the fisheries catch at the two selected sites of Beruwala 6^0 05'N, $80^0$01'E and Negombo 7^0 02'N 79^0 09'E on the west coast of Sri Lanka. The two sites were selected for monitoring because frequent cetacean catches had earlier been recorded at these sites and both accidental entanglement and intentional harpooning were known to occur. The chosen parameters were examined using a statistical approach as it was felt that such a study would contribute important information towards an understanding of the impact of the catch on populations of small cetaceans in Sri Lanka's waters. The results obtained will provide a base for more longterm studies which are necessary for formulation of a comprehensive, rational management and/or conservation plan for small cetaceans in Sri Lanka.

2. Methodology

The small cetacean catch was monitored on ten fishing days per month at each site for a period of six consecutive months from May to October 1994. The species, sex, total length and capture method were recorded for each specimen of small cetacean in the catch on these monitoring days. Species were identified using LEATHERWOOD and REEVES(1983), specimens were sexed by examining external genitalia, the total length (tip of snout to fluke notch) was measured using a 12 meter, steel measuring tape held taut and method of capture was determined by the presence of net marks or external harpoon wounds.

The numbers caught for each sex were computed to determine the sex ratio of the catch and an X^2 test of Independence (BRUNING and KINTZ 1987) was used to determine if there were significant differences between sites. Length measurements were examined to compute maximum length, minimum length, mean and standard deviation for each sex of each species. Significant size differences between sexes of each species and differences between sites within species were statistically examined by means of a t-Test for differences between two independent means with unequal differences (BRUNING and KINTZ 1987). Stage of maturity at capture was examined by categorizing data on length (only in species where more than ten specimens were recorded) into three stages of juvenile (upto 50cm from length at birth), sub-adult (from length at upper limit of juvenile category and length at sexual maturity) and adult (length at sexual maturity and above), (LEATHERWOOD and REEVES 1983). Once this was computed it was further divided according to method of capture and statistically analyzed using a complex chi-square and contingency coefficient (c) test (BRUNING and KINTZ 1987) to determine if there exists a correlation between maturity and capture method. In statistical computations level of significance was set at $P<0.05$.

3. Results

Sex Ratio

A total of 588 specimens (325 specimens of 12 species at Beruwala and 263 specimens of nine species at Negombo) were recorded and of these 313 were females and 275 males. Of the recorded catch at Beruwala 58.2% were females and 41.85% males while at Negombo 47.1% were females and 52.9% were males (Table I). The most common species in the catch at both sites was the Spinner dolphin *(Stenella longirostris)*. For species where more than five specimens were recorded per site, more females of *S. longirostris* and *Tursiops truncatus* were caught at both sites (Figures 2a & 2b). Beruwala had a larger percentage of females in four other species - *Stenella coeruleoalba* (56.8%), *Stenella attenuata* (52.4%), *Grampus griseus* (58.1%) and *Peponocephala electra* (66.7%) while another species *Steno bredanensis* had an equal percentage of males and females in the catch. At Negombo four species - *S. coeruleoalba* (64.7%), *S. attenuata* (62.5%), *G. griseus* (59.1%) and *S. bredanensis* (77.8%) had a higher percentage of males in the catch unlike at Beruwala (Table I).

Statistically the differences between the proportions of sexes caught at the two sites was significant ($X^2=7.072$, df=1, $P<0.01$).

Size Differences

In all species where both males and females were recorded the average length of females was greater than that of males, except in *S. bredanensis* where the average length of males was greater (Table II). The specimen with the maximum recorded length for each species was a female in most species with a male being the largest specimen only in the three species *S. coeruleoalba, Feresa attenuata* and *Kogia breviceps* (Table II). However, no statistically significant differences in size between sexes was observed in any of the recorded species. There was a statistically significant difference in size between sites for *S. longirostris* males and *T. truncatus* females that were caught ($t=2.221$, $df=154$, $P<0.05$ and $t=2.560$, $df=26$, $P<0.02$ respectively). There was no significant length variation between sites for other species.

In the majority of the six most commonly caught species larger percentages of juveniles and sub-adults were caught in comparison to adults (Table III). Most specimens of *S. longirostris, S. attenuata* and *T. truncatus* were sub-adults (41.3%, 45.9%, 52.9%), while for *S. coeruleoalba* and *G. griseus* most were juveniles (63.9%, 56.6%). Only in the species S. *bredanensis* more adults were caught (80.0%) and no juveniles were caught (Table III). Of the total recorded catch at Beruwala and Negombo, 154 (47.4%) and 119 (45.2%) respectively were intentionally harpooned while 171 (52.6%) at Beruwala and 144 (54.8%) at Negombo were a result of incidental entrapment in nets (Table IV). There was no statistically significant correlation between capture method and stage of maturity in the total recorded catch ($X^2=1.437$, $df=2$, $P<0.50$, $C=0.049$) or in the most commonly caught species *S. longirostris* ($X^2=2.255$, $df=2$, $P<0.75$, $C=0.080$) (Table IV).

4. Discussion

Statistical analysis of data on any aspect of the small cetacean catch in Sri Lanka was undertaken for the first time in the present study. Examination of sex ratios of the small cetacean catch in the present study indicates that more females than males were caught at Beruwala. DAYARATNE and JOSEPH (1993) found an overall higher percentage of males in the catch from all areas monitored by them. However, they also report that there was some variation between species in particular areas when they stated that "Females outnumbered males in overall sex ratio of Striped doiphins in the northeast and Spinner dolphins and Bottle-nose dolphins in the west". Statistical comparison of sex ratios in the present study revealed

that the overal number of females caught at Beruwala is significantly higher than the number of males. Previous studies on small cetaceans in Sri Lanka have not examined this statistically and therefore comparison between those studies and the results of the present study is difficult. A possible explanation for the female bias in the catch at Beruwala in the present study could be that females are more vulnerable to capture in the process of protecting their young. WATSON (1981) reports that all female cetaceans take great care of their offspring, continuing to shelter them in times of danger even after they have been weaned.

When examined statistically, there was no significant sexual dimorphism with regard to length in any of the species recorded in the present study. LEATHEWOOD and REEVES (1989) reporting on the catch of small cetaceans in Trincomalee (east coast) found the average length of males in *S. longirostris, S. coeruleoalba, S. attenuata* and *G. griseus* was greater than the average length for females while the opposite was so for *T. truncatus* and *F. attenuata* with the average length of females being greater. However, these conclusions were drawn without testing the data statistically. According to the natural history for the five most common species recorded in the present study, sexual dimorphism occurs only in *T. truncatus,* where males may grow slightly larger than females (LEATHERWOOD and REEVES 1983). The results of the present study confirms this.

In the present study males of the most common species *S. longirostris* caught at Beruwala were significantly larger than those caught at Negombo, whereas females of *T. truncatus* caught at Negombo were significantly larger than those caught at Beruwala. Several forms (coastal and offshore) of *S. longirostris* have been described from the eastern tropical Pacific (PERRIN 1972; LEATHERWOOD and REEVES 1983), and of *T. truncatus* in the north Pacific (LEATHERWOOD *et. al.* 1982). These forms differ in size as well as other features such as color. Parallel research has not been done in the Indian Ocean and the size differences recorded in the present study may be indicative of a similar natural variation. Although the two study sites are not situated at a great distance from each other (90 km on land) the size difference within species could be attributed to two forms: coastal and offshore. However, the present data is insufficient for definitive conclusions.

Examination of length categories most vulnerable to capture in the present study revealed that 70.8% of the catch of *S. longirostris* comprised of sub-adults and juveniles. This indicates that this species is less vulnerable to capture after they reach sexual maturity. In offshore sightings of this species which is common off Sri Lanka, sub-adults are more active,

acrobatic and exploratory in their behavior around boats than mature adults (ILANGAKOON 1996). This behavior probably makes them more vulnerable to both harpooning and net entanglement than adults. Continuous depletion of juveniles and sub- adults from a population could lead to an eventual dearth of breeding adults and no replacement to the population.

In *S. coeruleoalba* over 60% of the catch were juveniles and interestingly in the present study, five of the recorded specimens were below 100 cm in length indicating that the length at birth of this species, in the India Ocean around Sri Lanka, may be less than the average length at birth recorded in the Pacific and Atlantic oceans. Results of the present study also confirm DAYARATNE and JOSEPH (1993) view that ".....around 70 percent of Striped dolphin landings in Sri Lanka could be immature (less than 190 cm length)." Schools of this species are known to segregate into length classes elsewhere (LEATHERWOOD and REEVES 1983) and it is likely that the behavior of juveniles makes them more vulnerable to capture. Again it should be noted that depletion of juveniles over time, negates natural replacement to the population. For *S. attenuata* more sub-adults and adults were caught in the present study. DAYARATNE and JOSEPH (1993) found nearly 70% of the catch to be mature animals but they categorized on the basis of length at maturity being only 160 cm. which differs from LEATHERWOOD and REEVES (1983) on which the categories of the present study are based.

The results of the present study indicated that in *T. truncatus* too sub-adults are more vulnerable to capture. When encountered in offshore sightings, the adults of this species were often in small groups of less than ten individuals, whereas sub-adults and juveniles were seen in much larger groupings. The small adult groups may have acquired skills of avoiding nets and are probably less vulnerable to harpooning due to small numbers and the absence of juveniles to slow them down. DAYARATNE and JOSEPH (1993) have also stated that "Over 90 percent of Bottle-nose dolphin landings in Sri Lanka could be immature (less than 250 cm)." Here again length of maturity (250 cm) differs from LEATHERWOOD and REEVES (1983) on which the present study is based. In *G. griseus* over 95% of specimens recorded in the present study were juveniles and sub-adults, confirming findings of DAYARATNE and JOSEPH (1993) that over 90% of landings in this species could be immature. Eight specimens recorded in the present study were below 150 cm in length indicating that in this species too length at birth may be less in the Indian Ocean than the average recorded in other oceans. *S. bredanensis* was the only species with the most vulnerable category being mature adults.

Examination of length category in relation to method of capture indicated no statistically significant correlation. Therefore it is apparent that the method of capture is not a factor that determines the vulnerability of particular size groups in each species.

From the results of this study it can be concluded that at least at one site monitored (Beruwala) more females are being caught which also means that more reproductive or potentially reproductive animals are being killed. It can also be concluded that each of the more commonly caught species has a particularly vulnerable size category which in the majority of species is juveniles or sub-adults. This must have an effect on the population eventually as only post-reproductive animals can be continuously lost from a population without having an effect on the recruitment rate of the population itself. This is bound to have an adverse effect on populations, specially on small cetacean populations because of their naturally slow reproductive rate. It can also be concluded that size is not a criteria on which fishermen harpoon dolphins as there was no correlation between capture method and size category. Therefore both accidental and intentional catch of small cetaceans is indiscriminate with regard to sex and size and must ultimately have an adverse effect on populations if it is not controlled in time.

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TABLE I
Sex Variataion in the Small Cetacean Catch By Species and Site

Species	Beruwala				Negombo			
	Number		percentage		Number		Percentage	
	F	M	F	M	F	M	F	M
Slo	109	75	59.2%	40.8%	84	81	50.9%	49.1%
Sco	25	19	56.8%	43.2%	6	11	35.3%	64.7%
Sat	11	10	52.4%	47.6%	6	10	37.5%	62.5%
Ttr	14	11	56.0%	44.0%	14	12	53.8%	46.2%
Ggr	18	13	58.1%	41.9%	9	13	40.9%	59.1%
Pel	4	2	66.7%	33.3%	1	0	-	-
Pcr	3	0	-	-	0	0	-	-
Fat	0	1	-	-	1	2	-	-
Kbr	1	1	-	-	0	0	-	-
Ksi	0	1	-	-	0	0	-	-
Sbr	3	3	50.0%	50.0%	2	7	22.2%	77.8%
Lho	1	0	-	-	1	3	-	-
Total	189	136	58.2%	41.8%	124	139	47.1%	52.9%

Note : Species names in the the above table and all other tables in this paper are abreviated as;

Slo = Stenella longirostris, Sco=Stenella coeruleoalba, Sat = Stenella attenuata, Ttr = Tursiops truncatus, Ggr=Grampus griseus, Pel = Peponocephala electra, Pcr = Pseudorca crassidens, Fat=Feresa attenuata, Kbr = Kogia breviceps, Ksi = Kogia simus, Sbr=Steno bredanensis, Lho=Lagenodelphis hosei. F = Female, M=Male

TABLE II
Length Variation in Small Cetacean Catch by Species, Sex and Site

Species	Mean Length± Standard Deviation (cm)		Mean Length± Standard Deviation (cm)	
	Female	Male	Beruwala	Negombo
Slo	153±30 (86-241)	147±30 (95-241)	155±31 (87-241)	145±29 (86-230)
Sco	152±40 (100-220)	143±46 (98-238)	154±47 (98-238)	133±24 (108-192)
Sat	188±21 (148-220)	172±36 (97-212)	179±30 (97-220)	182±30 (128-219)
Ttr	194±55 (89-293)	188±52 (120-293)	170±50 (89-293)	211±49 (120-293)
Ggr	206±53 (130-308)	193±46 (120-288)	203±49 (120-307)	195±51 (130-308)
Pel	224±18 (204-253)	205±16 (189-221)	216±20 (189-253)	233 - (233)
Pcr	212±56 (240-370)	- - - -	- - - -	- - - -
Fat	225 - (225)	204±25 (170-230)	213 - (213)	208±27 (170-230)
Kbr	193 - (193)	242 - (242)	- - - -	- - - -
Ksi	- - - -	180 - (180)	- - - -	- - - -
Sbr	200±25 (170-233)	215±14 (178-230)	201±23 (170-233)	215±15 (177-230)
Lho	230±7 (223-236)	226±1 (225-227)	223 - (223)	228±5 (225-236)

Note : Length range is given in paranthesis and - indicates no data recorded.

TABLE III
Numbers of Small Cetaceans in the Catch in Relation to Length Range and Maturity for Commonly Caught Species

Species and Category of Maturity	Length Range (cm)	Specimens Recorded Number	Percentage
S. longirostris			
Juveniles	<130	103	30%
Sub-adults	130-170	144	41%
Adults	>170	102	29%
S. coeruleoalba			
Juveniles	<150	39	64%
Sub-adults	150-180	5	8%
Adults	>180	17	28%
S. attenuata			
Juveniles	<140	6	16%
Sub-adults	140-190(F) 140-200(M)	17	46%
Adults	>190 (F) >200 (M)	14	38%
T. truncatus			
Juveniles	<150	15	29%
Sub-adults	150-250(F) 150-230 (M)	27	53%
Adults	>250(F) >230(M)	9	18%
G. griseus			
Juveniles	<200	30	57%
Sub-adults	200-300	21	40%
Adults	>300	2	4%
S. bredanensis			
Juveniles	<140	0	0%
Sub-adults	140-180	3	20%
Adults	>180	12	80%

Note : (F) = female and (M) = male in species where length at sexual maturity differs between sexes.

TABLE IV
Capure Method of Small Cetaceans in the Catch in Relation to Site

	Total Recorded Catch			*Stenella longirostris*		
	Harpoon	Net	Total	Harpoon	Net	Total
Beruwala	154	171	325	96	88	184
Negombo	119	144	263	79	86	165
Total	273	315	588	175	174	349

Maturity in Relation to Capture Method of Small Cetaceans in the Catch

	Total Recorded Catch			*Stenella longirostris*		
	Harpoon	Net	Total	Harpoon	Net	Total
Juvenile	87	106	193	44	59	103
Sub-adult	113	117	230	70	74	144
Adult	75	90	165	40	62	102
Total	275	313	588	154	195	349